Type 1a Supernovae

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Supernova Types

- Classified by absorption lines
- Core Collapse
  - Stripped Core (Ib and Ic)
    - Ib have lost H layer
    - Ic have lost He layer too
  - Full explosion (II)
- Thermonuclear
  - Type Ia
  - “Carbon Bomb”

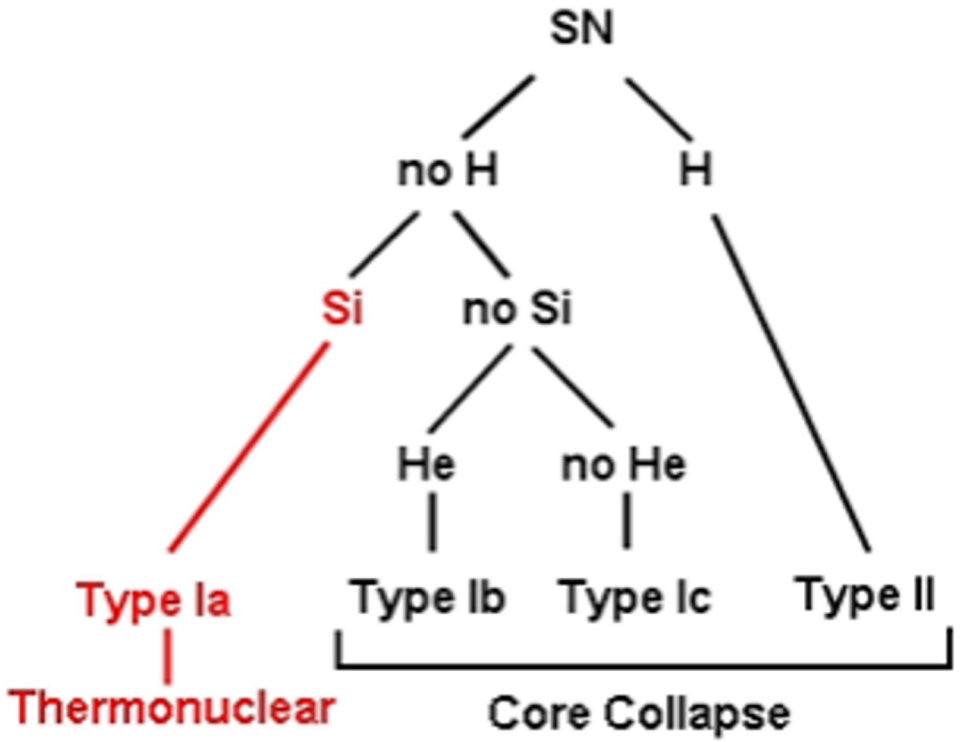


Image: Swinburne Institute of Technology: COSMOS

Type 1a Supernovae

- Chandrasekhar mass
  - Core Temp ↑
  - Carbon Fusion
  - Temp ↑
  - Oxygen Fusion
  - Temp ↑ Temp ↑ Temp ↑
- Also: white dwarf mergers

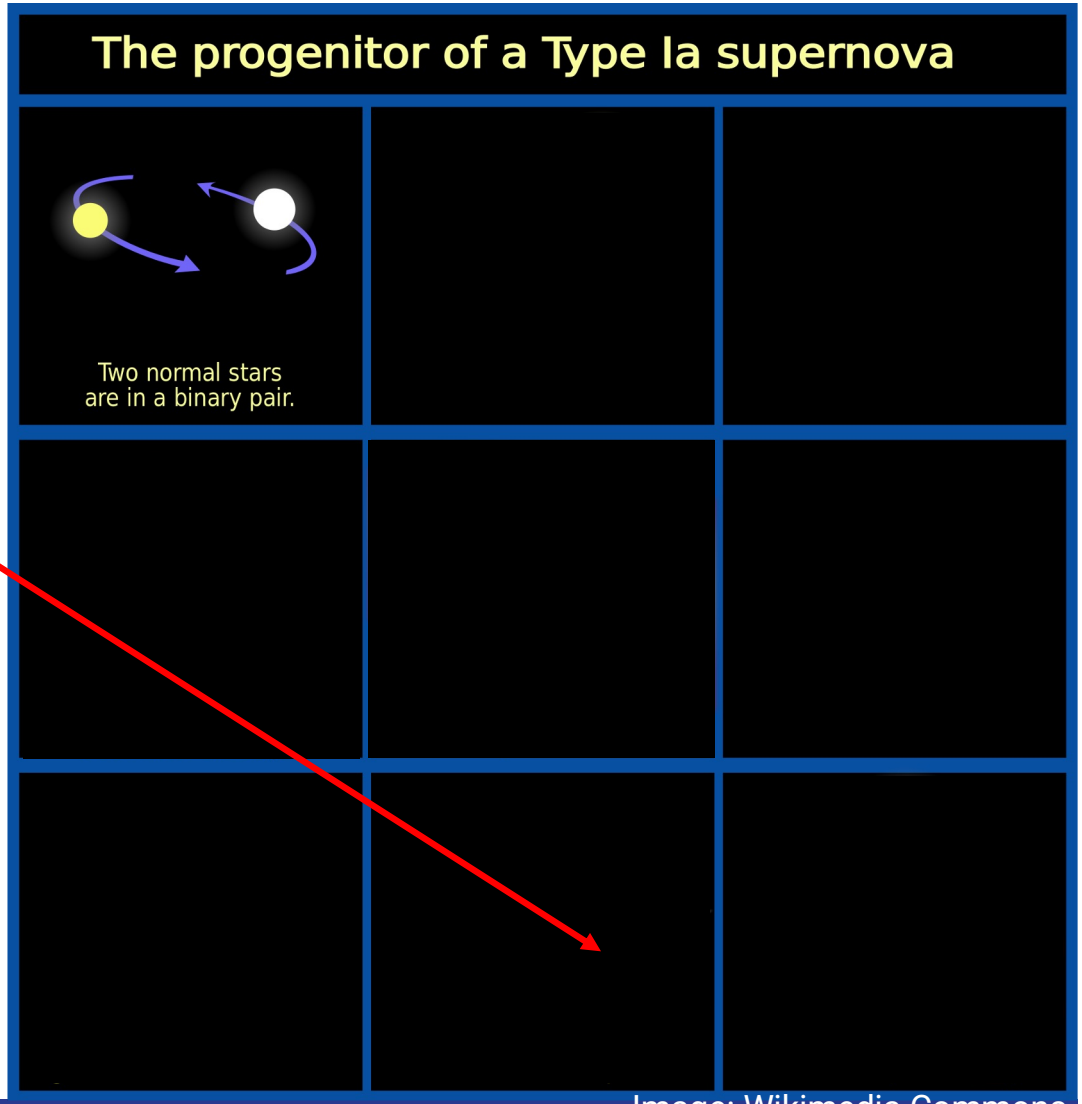
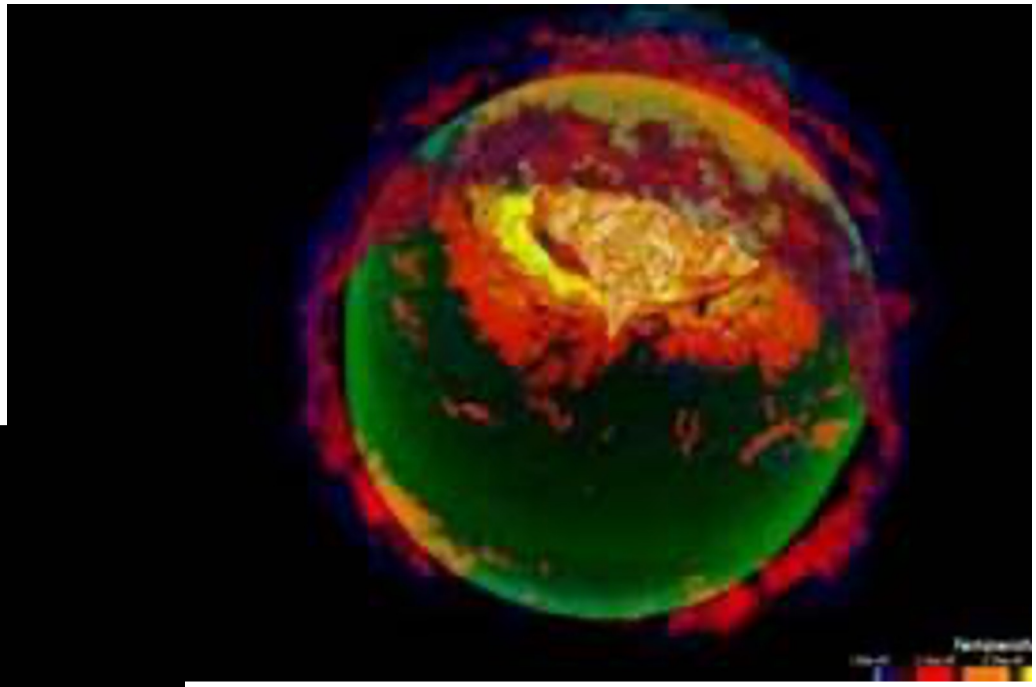
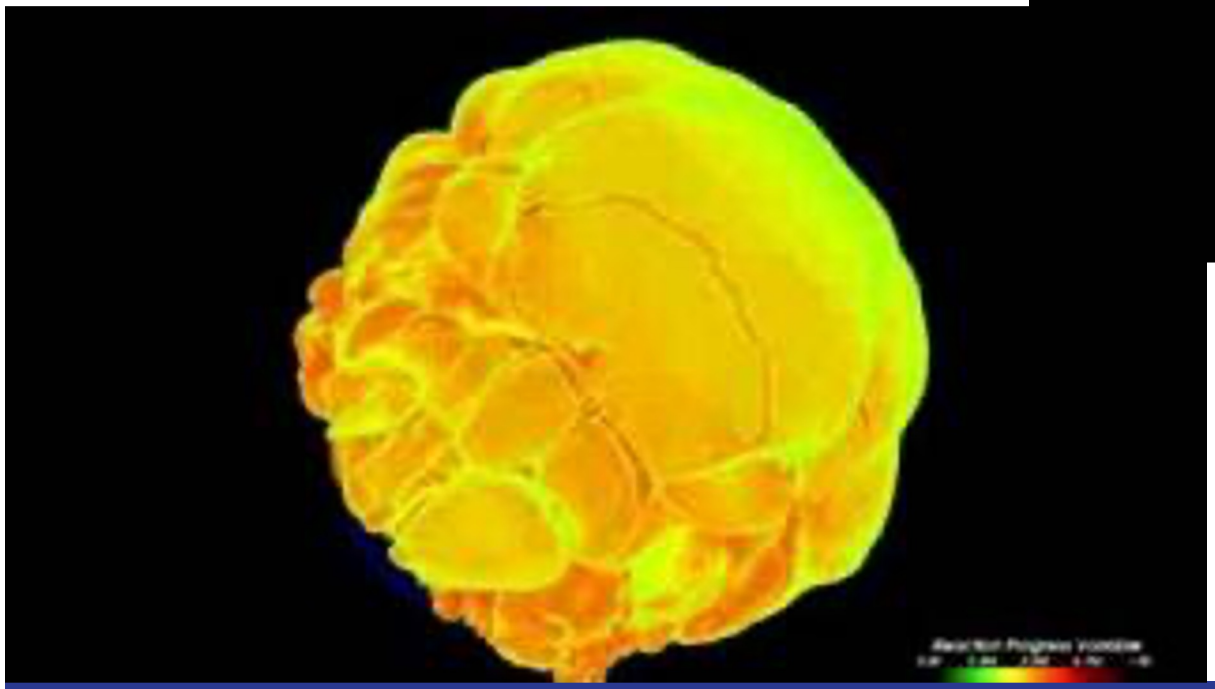


Image: Wikimedia Commons

Shall we watch one?





Videos: Jordan+, 2007

Effects

- Huge energy release
- Ejecta blasted at 5 - 20 Mm/s
  - (2 - 6% c)
- No more star

- NOT a “novae”
  - WD accreting slower
  - No Chandrasekhar limit
  - Small H bomb

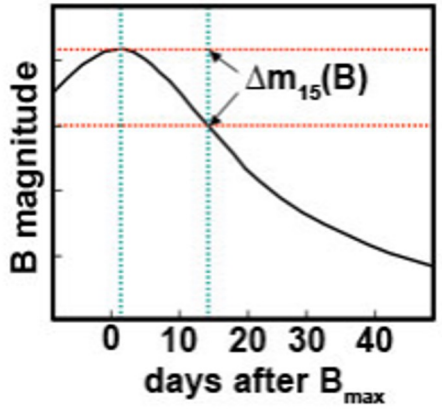
Plot: Swinburne Institute of Technology: COSMOS

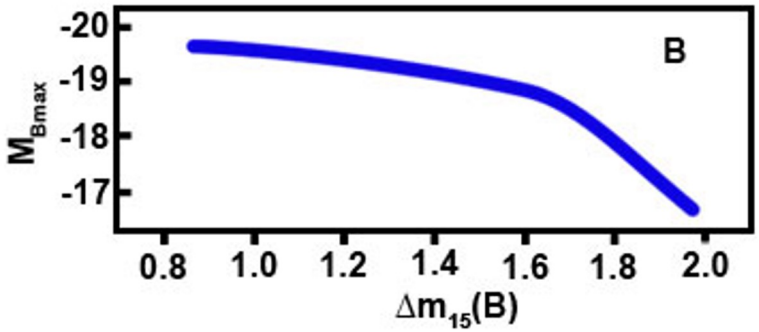
Why type 1a?

- Bright
  - 10^{44} J (10^{51} ergs)
  - M = -19.5 σ ~ 2 mags
  - m = 20 at 800 Mpc
- Consistent
  - $\lesssim 1.44\ M_{\odot}$
  - Standard Candle!
  - **Not identical**

The secret

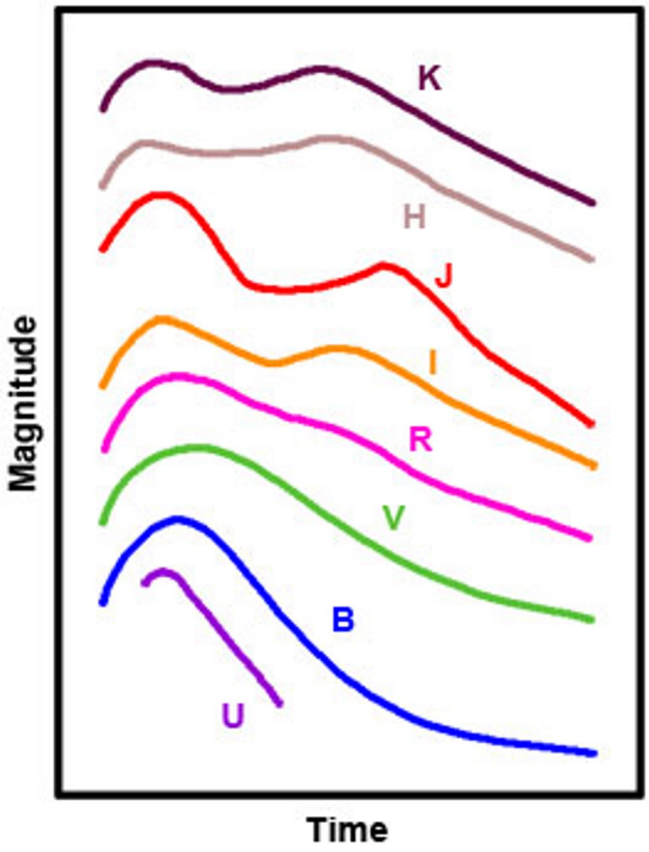
- Luminosity-Decline Rate Relation
  - Mark Phillips (1993)
  - Brighter explosions last longer than Dimmer ones
  - Comparison #'s from nearby SNe
- 3 methods
  - Δm_{15} →
  - Multicoloured Light Curve Shapes (MLCS)
  - Stretch Factor





Plot: Swinburne Institute of Technology: COSMOS

MLCS method

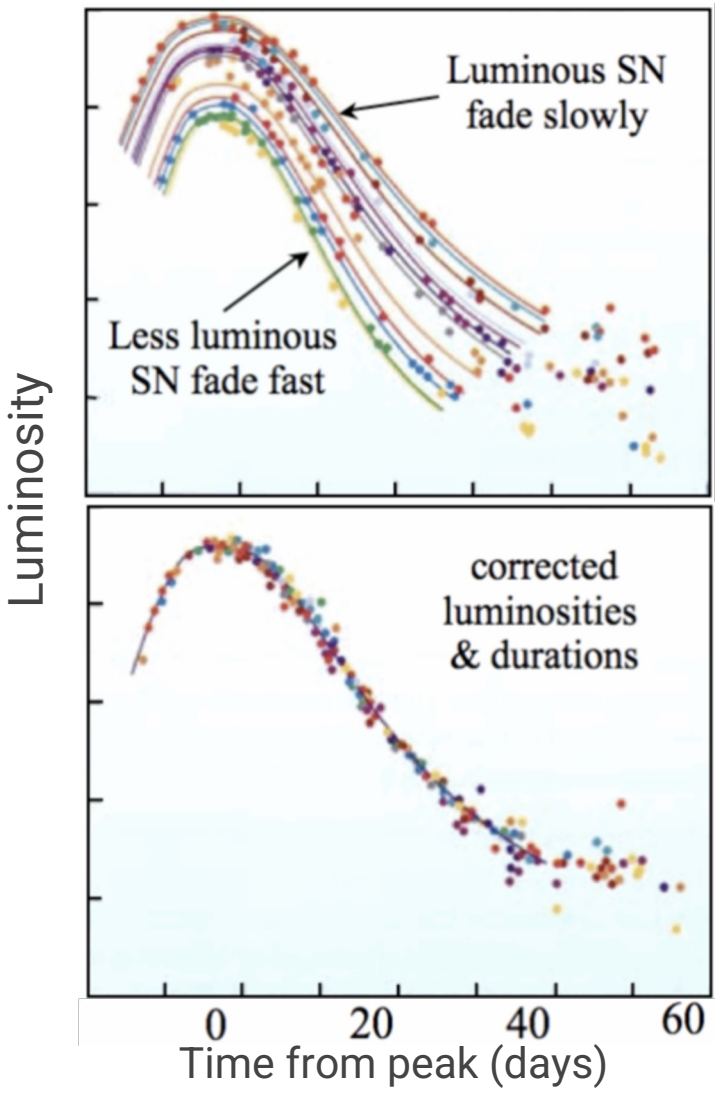


- All converge to the same color
  - De-reddening
- Dimmer SNe are redder
  - Relation gives absolute mag
  - Huzzah!

Plot: Swinburne Institute of Technology: COSMOS

Stretch Factor Method

- Fit slope of exponential dropoff
  - Same shape
- Fit maximum luminosity
  - Huzzah!



Plot: Durham University Department of Physics

Limitations

- σ ≲ .12 mags
  - Distance accuracy to ~ 5%
- Rare
  - 1 per ~500 years in MW
  - Need a lot of stars

$$\frac{.19 \pm .09\ Supernovae}{10^{10} L_{\odot}^{B} \cdot Century}$$

(Hamuy & Pinto 1999)

Distances & Targets

- As far as you can resolve
  - m = 20 at 800 Mpc
  - m = 27.7 at 27 Gpc
    - Subaru deep field - Ground based
  - m = 31.5 at 158 Gpc (Hubble)
  - Realistically ~1 Gpc
- Need **many** stars
  - Galaxy clusters

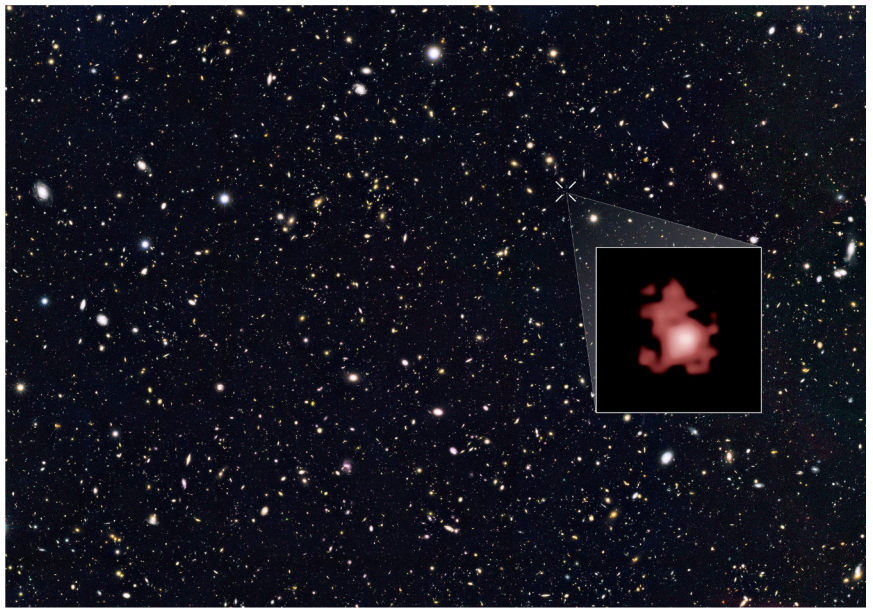
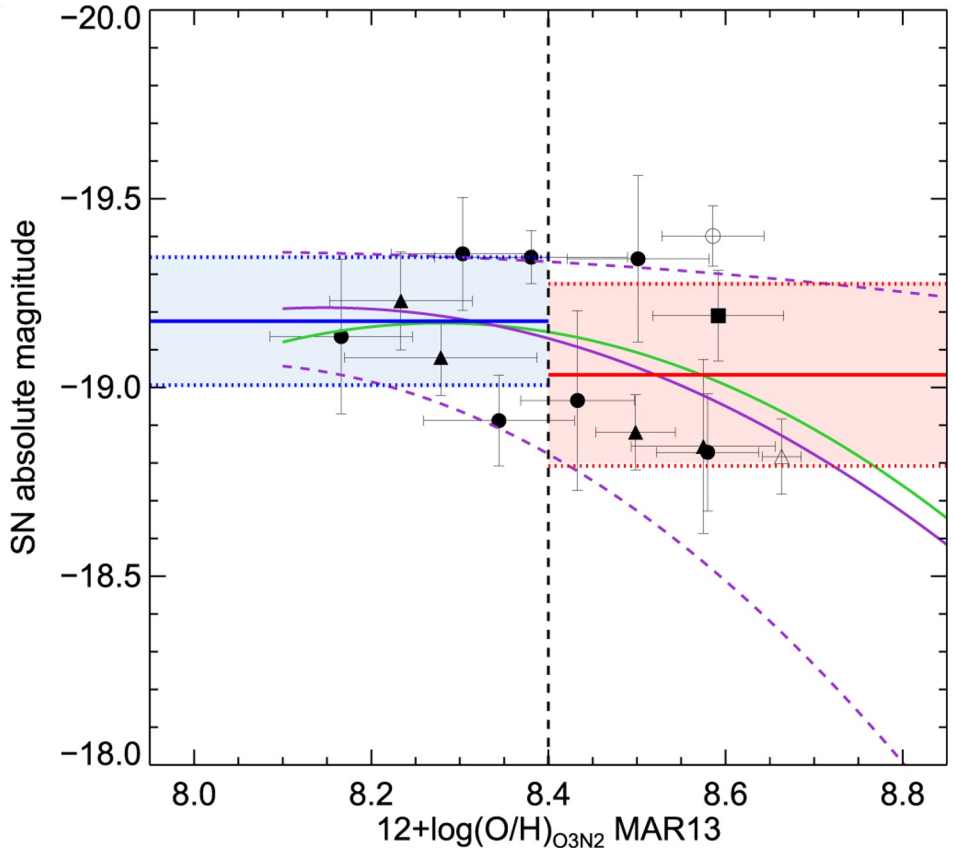


Image: NASA Hubble

Errors

- Metallicity Dependence
  - Very small
- Errors in the fit (of course)
  - Estimated ~ .05 mags (Saunders+, 2015)
- Different populations
  - 0.121 ± 0.010 mag (Briday+, 2021)



Plot: Moreno-Raya+

Recent Results

- A BayeSN distance ladder: H0 from a consistent modelling of Type Ia supernovae from the optical to the near-infrared (Dhawan+, 2023)
  - Calibrate 67 Type Ia SNe in the optical and NIR
  - H0 = 74.82 ± 0.97 (Cepheid distances), 70.92 ± 1.14 (TRGB distances)
  - 15% uncertainty reduction from single-band (optical or NIR)

References

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